

THE DEVELOPMENT
OF THE
ANIMAL KINGDOM:
A PAPER

READ AT THE FOURTH MEETING OF THE
ASSOCIATION FOR THE ADVANCEMENT OF WOMAN

BY GRACEANNA LEWIS.

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The Development of the Animal Kingdom.

Naturalists, whatever may be their opinions on the question of Evolution, unite in believing in the existence of an ORDER OF RELATIONSHIP in the animal world. To trace this order and to seek its cause is one of the most interesting occupations which can engage the human mind, and is one well worthy of honest study through life, even if but little apparent progress should be made therein.

It is not possible to study Animal Life effectively without a general knowledge of its co-related branch, Vegetable Life; nor the System of Life as a whole without some attention to the Mineral Kingdom; nor can either Kingdom be fairly understood without due consideration of the Laws which control matter. The Physicist must aid the Biologist; and on their conclusions both the Botanist and Zoologist are largely dependent. Each science enriches the other, and we who can devote ourselves to but one gladly acknowledge our indebtedness to all who bestow their help.

That Power which called us into being has endowed us with the desire to grasp thread after thread of knowledge, that we may hold them as clues to guide us through the labyrinths of unrevealed mysteries. We are obeying the dictates of the Soul when we follow their leading. The faculties which distinguish between things which are like and those which are unlike make of us classifiers, and we think of the class, rather than of the individuals which compose it. Thus we are enabled to take a general survey of Nature.

When we speak of the mineral kingdom, the vegetable kingdom, or the animal kingdom, we remember that, in fact, vegetable and animal organisms are not distinctly separable, and that no man knows the conditions necessary for the production of either from their chemical components. We are also reminded that the distinctions between *animate* and *inanimate* matter cannot be too strongly insisted upon.

Protoplasm, formed by the combination of so many atoms of Carbon, Hydrogen, Oxygen, and Nitrogen,—inanimate gases,—exists in all animate forms, whether these be of the vegetable or of the animal kingdom. Mineral compounds may be formed with exactly the same chemical constitution. *Where* does life arise, and whence comes its activity? The mind goes beyond these compounds to find that activity in the MOTIONS belonging to atoms of matter.

The ATOM is understood to be the material representative of Divine Energy,—the Germ of Being,—and to contain, in combination with other atoms, all the possibilities of the whole Life-System. If we adopt the idea that atoms partake of the eternal energy of the

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Supreme Ruler of the Universe, who both called them into being and planned for them an infinity of combinations, we are prepared to consider the multiplicity of forms which are in existence, and to find in them all some binding principle of relationship.

Atoms, like magnets, are supposed to possess attractive and repellant poles, and to retain in combination both vibratory and rotary motions. Atoms which are held together by their *axes of rotation* are believed to give lines of MAGNETIC FORCE. Molecules, formed of atoms, possess similar polarities; as do particles and masses of matter.

Magnetism acts *end to end*, and, since it holds matter to a central axis, it is a CENTRIPETAL FORCE. Other forces distribute from a centre, and are CENTRIFUGAL FORCES.

Light is electro-magnetic, and may combine in itself both the centripetal and centrifugal forces, moving in accordance with these dual forces, all matter on which it acts.

The CRYSTALLIZING FORCES, which arrange mineral substances in definite order, according to the attractive and repellant polarities of their molecules, act so similarly to Light as to suggest the operation of either identical or analogous laws.

The VITAL FORCES, which control the system of life, operate in harmony with Light, and also with the Crystallizing Forces.

Therefore it may be understood that the centripetal and centrifugal forces in nature, similarly, act upon mineral, vegetable, and animal forms. It may indeed be assumed that all forms are modifications of the

sphere resulting from the action of these two classes of forces.

The primary structural forms which are built up under their action are the *crystal* in the mineral, and the *cell* in the vegetable and animal kingdoms. Mineral masses are built of crystals; and cells form every higher structure in the vegetable and animal kingdoms.

Crystals are united in masses under laws which govern the primary forms: animate beings cannot escape from the action of the polarizing forces, although these may be modified by the action of the Vital Forces.

In the water-crystal the main axis is perpendicular to the plane of crystallization, or, in other words, it is at *right angles to the branches*. In their plane of crystallization snow-crystals may present a series of triangles. A snow-crystal of six rays may be a double triangle. There may be twelve or more points, the beauty usually depending on the complexity of design. Each point has its own axis, which governs the symmetrical disposition of the parts, but the design is similar in circles of six rays each. In the crystal the centripetal and centrifugal forces are modified by molecular action.

In the flower, the essential parts, the stamen, pistil, and ovary, are in the axis of growth. The less important corolla diverges from the centre, as do the rays of the snow-crystal. In the fruit, the line connecting the stem and blossom ends, corresponds to the perpendicular axis of the snow-flake, the seeds being disposed by various methods around that axis.

In the tree, the main trunk is the axis of growth; the branches diverge from this axis under the same law which sends the molecules of water on their divergent paths of crystallization. Each branch of the tree has its special axis, from which the minor branches diverge; and leaves ray from the branch as the branch rays from the stem, the ribs of the leaf following the same general law of divergence. In the plant we see the action of centripetal and centrifugal forces, controlled by Growth Force.

A large proportion of the Protozoans and Radiates resemble crystals in form. Some of them, especially among Rhizopods, are strikingly similar to crystals. The limbs of animals correspond to the branches of plants. They bud at right angles to the axis of growth, but may be modified so as to become parallel with it, as in the lower extremities of man.

In the *Groups of animals*, as well as in the individual forms, we find evidence of the operation of the same laws. There is a well-defined axis, and there is a circle of radiation in every great group. The branches of such groups are related to each other by characters which make it impossible to confound them with members of a higher circle.

These circles—or, more accurately, coils of ascending spirals—represent the disposition of the rays of a color disk, the plane of crystallization of a water-crystal, the branches of trees, the disk of a flower, the seeds of a fruit, the symmetrical parts of a radiate animal,—all alike due to the great law of Phyllotaxis, resulting from the dual action of the centripetal and centrifugal forces in nature.

The ORDER OF DEVELOPMENT in the animal kingdom, is from the lower to the higher. The coils of ascent around a central stem are formed *by a system of dichotomous branches at right angles to each other*. The alternating pairs of branches compose one circle of four rays of related animals, with a central stem of higher forms. The higher stem is analogous to the perpendicular axis of the snow-flake ; to the trunk of a tree ; to the earth's axis of rotation ; to the centre of rotation of the planetary system ; and to every axis of rotation in nature.

Beginning with the lowest organisms, the *Plastides* of Haeckel may be considered as the root of the animal kingdom. These organisms are scarcely, if at all, separable from Plant-Life, and barely removed from the mineral kingdom. From this root diverge four great groups of PROTOZOANS. The first pair of branches are the POLYCYSTINES and SPONGES, together comprising the *Actinozoids*. The Polycystines, among animals, represent the *Diatoms* of the vegetable kingdom ; and the Sponges are also analogous to plants. The Diatoms, Polycystines, and some of the Sponges are siliceous, when there are hard parts. Prof. Agassiz went to his grave doubting whether the Sponges should be classed among Plants or Animals. These doubts are not generally shared by naturalists, and some consider the Sponges among the more highly organized of Protozoans.

The next pair of branches are the RHIZOPODS or Root-footed animalculæ, and the INFUSORIA. The Rhizopods, in certain external characters, foreshadow the Mollusca, especially the cephalopods. They are

sometimes called *Malacazoids* because, like the molluscs, their hard parts are of carbonate of lime. In like manner the Infusorians suggest the Articulates, and are known as *Entomozoids*.

The Polycystines connect with their neighbors the Rhizopods; and in the same way the Sponges connect with the Infusorians, thus completing the coil of ascent, as the Infusorians are, clearly, the most highly organized of Protozoans.

The Protozoans appeared earliest in Time, the oldest of known fossils being Eozoon, belonging to the rocks of the Pre-Cambrian Period.

From the Protozoans arise a central stem of METAZOANS, of which the branches lowest in structure are the CŒLENTERATA (Corals and Allies), and the ECHINODERMATA (Star-Fishes, &c.) This pair of branches constitute the "Radiata," although the Echinoderms and even the higher Cœlenterates manifest a degree of bi-laterality.

The succeeding pair of branches in this invertebrate circle, are the MOLLUSCA and ARTICULATA. Of these Agassiz remarks, "We cannot predicate absolute superiority or inferiority of organization of either group as compared with the other; they stand on one structural level, though with different tendencies." This is entirely consistent with the idea that they are opposite and complementary members of one pair, in a system of dichotomous branching.

The Cœlenterates (through the Polyps) connect so closely with the Sponges below them that the best palæontologists hesitate to say of certain ancient forms whether they are sponges or coral.

The Mollusca, on one side connect with the Coelenterates, through the branches known as Molluscoidea, and especially by the Polyzoa; and on the other side the Cephalopods rest upon an Echinodermatous base.

The Worms by their lowest branch, the *Rotifera*, touch upon the Infusoria; they also through other forms connect with ancient Echinoderms, while by their complete circulation the highest branch, the *Annelida*, approaches the vertebrates.

Molluscan and Articulate forms sometimes resemble each other so closely that it has required the most profound research to distinguish between the two.

All four of these invertebrate branches diverge from a common stem; hence these resemblances to each other, and to their Protozoan stock.

The Articulates appeared in the Lower Cambrian;—in America, with the genus *Paradoxoides*. The lower Molluscs and Radiates followed during the deposition of rocks of the Cambrian and Lower Silurian Periods, but it was not until later, at the base of the Upper Silurian, that the Cephalopods entered upon existence.

With the Upper Silurian, the VERTEBRATE Stem budded from the invertebrate base.

Some of the earliest vertebrates of the family *Cephalaspidæ* remind us curiously of both the TRILOBITES and the *Orthoceratidæ*,—that is, of both Articulate and Molluscan forms.

The vertebrate which is lowest in structure, but which belongs to a later period, appears to have taken its rise from the opposite side and to be derived from the Coelenterates and lower Molluscans.

All molluscs, articulates, and vertebrates are bilateral

in structure ; that is, their parts are symmetrically arranged on either side of a longitudinal axis. *Two end-ness* has gained the mastery over the sphere. There are here an *anterior* and a *posterior* pole, and these usually correspond to the head and tail of the animal, although the lower mollusca are headless.

The great stem of the VERTEBRATA divides, primarily, into four lateral branches, with a fifth central stem, destined to produce the most important vertebrate forms. The primary whorl, composed of these lateral branches, includes fish-like animals which are entirely distinct from the true fishes. The lowest in grade of these generalized vertebrates is the Lancelet, or *Amphioxus*, forming the division PHARYNGOBRANCHII, or LEPTOCARDIA. This is the animal which during its embryological development recalls the Coelenterata and lower Mollusca, and reaches maturity with no resemblance to any but an embryonic vertebrate. It is without vertebra, possessing only the noto-chord which is transitory in other vertebrates. No fossil Leptocardia are known. It is reasonable, but not necessary, to conclude that it must have come into existence early in time. In many other instances, forms low in structure have appeared at comparatively late geologic eras.

The MARSIPOBRANCHII, or the Lamprey Eels, are the next in order. Although no fossil forms are known, they, in some respects, approximate the earliest of the Silurian vertebrates.

The ELASMOBRANCHII (Sharks, Rays, and Chimœras), unlike the Leptocardia and Marsipobranchii, came early into existence, occurring in the Upper Silurian

rocks, and continuing by successive forms to the present time.

These are followed in structural order by the DIPNOI, or Mud-Fishes, animals which breathe by true lungs, as do the Reptiles. The spinal column and the limbs of the Dipnoans approximate to those of the most ancient of the Crossopterygian Ganoids, and the animals approach the Amphibians even more closely than they do the true Fishes.

These four branches of generalized vertebrates form a coil around a central stem of Ganoids, which, as ICHTHYOPSIDA, lead up to the more highly specialized vertebrate classes.

From this main stem of the Ganoids, in the Carboniferous Period, animals with amphibian tendencies began to branch, but it was not until a vast interval of time—in the Cretaceous, that the true bony fishes came upon the scene. The whole group of Ichthyopsida, including the Fishes and Amphibians, appears to arise intermediately between the Elasmobranchii and the Dipnoans. The Amphibians, although on a higher plane than the Fishes, seem to express the possibilities of structure residing in a group whose root is between the Leptocardia and the Dipnoans, whilst the fishes lean to the side of the Elasmobranchii.

Below the Permian, no *Sauropsida* are known. Branching from the Ganoid stem, they developed in force during the Triassic and Jurassic Periods, and gave rise to modern reptiles and birds.

The Mammalian stem began to bud in the Triassic, with *Dromatherium*, and at least eleven genera of mammals were in existence before the appearance of

Archæopteryx, the earliest of the true birds, belonging to the Upper Oolite.

All of the early Ichthyopsidans and Sauropsidans were more or less mammalian in character. The difference between the hand-footed *Cheirotherium*, which left its tracks in the mud of the Lower Trias; the Labyrinthodonts and other Amphibians; the Protosauroids of the Permian, and other Triassic Sauropsida, and the Mammals, was not so great as might be anticipated by comparing modern representatives of these ancient forms. At the time when the mammals appeared with characters borrowed from both the great groups which preceded them, the four lateral branches of fishes, amphibians, reptiles, and birds had not attained their distinctive characters. These were the result of later development.

The class of MAMMALIA branches into three main divisions, known as ORNITHODELPHIA, DIDELPHIA, and MONODELPHIA.

The Ornithodelphia, or Monotremata, are the lowest and most bird-like of Mammals. They combine both Sauropsidan and Ichthyopsidan characters with those which distinguish the group to which they belong. They consist of two families only, each represented by a single genus, and belong to Australia. They are *Echidna*, or the Porcupine Ant-eater, of the family *Tachyglossidæ*; and *Ornithorhynchus*, Platypus, or the Duck Mole, of the family *Ornithorhynchidæ*. No fossil *Ornithodelphia* are known.

The DIDELPHIANS, or Marsupials are also a low grade of Mammals, with imperfect young. If divided according to the nature of their food, they constitute

three groups, HERBIVORA, CARNIVORA, and INSECTIVORA, which are again divisible into tribes and families. Thus among Herbivora there are Root-eaters, Grass-eaters, etc., with extinct forms which combined the characters of several groups. The Marsupials seem like a first essay of the higher mammals which appeared later. The Didelphians and the Monotremes constitute the Implacentals.

The families *Dromatheriidæ* and *Plagiaulacidæ*, which are Mesozoic mammals, are usually classed with the Didelphians. They may possibly be neither Ornithodelphians nor Didelphians, but, like these, distinct groups of generalized mammalian forms.

As we are wholly unacquainted with their internal organization, it is impossible to do more than conjecture whether or not they were implacentals. Like those comprehensive vertebrates, the viviparous sharks, they may have included species with a rudimentary placenta. It seems strongly probable that extinct forms carried up the line unbroken from the earliest vertebrates to the placental mammals.

The MONODELPHIANS, which are the placental mammals, arise as a main stem from the implacental base with a structure superior to these, carrying up, doubtless, characters derived from the earliest of vertebrates. They appeared in force during the Tertiary period, branching, in the Eocene, into their main divisions, although the *Edentates*, which are the lowest in structure, did not appear until later. The extinct Edentates belong to the later Tertiary and to the Quaternary Periods, and include the gigantic *Megatherium*, the huge *Glyptodon*, and other fossil animals. The

living Edentates are the Armadillos, Ant-eaters, and Sloths, species of which are found in South America, Southern Asia, and Africa.

Among Monodelphians, the Edentates recall not only implantal mammals, but Sauropsidans, at the same time that they manifest relationships to the Non-Deciduates, Zonarians, and Discoidans. Lying at the root of the Discoida, they sum up many preceding forms, but are apparently reversions rather than generalized Monodelphians.

The CETACEA, or Whales, may be regarded as the opposite members of the lower pair of branches of Monodelphians. In external form they represent the Fishes, as the *Glyptodon* among Edentates reminds us of the Tortoises.

The next pair of branches are the NON-DECIDUATES and ZONARIANS. The former includes *Sirenia*, *Ungulata*, and *Toxodontia*.

Sirenia (Manatees and Dugongs) descends to approximate the whales. The Toxodonts are an extinct Quaternary group approaching both the Sloths and the Bears, and also bearing relations to members of the Discoida. They must be regarded as an ascending group, in the same manner as *Sirenia* is a descending one.

The Ungulates, or hoofed animals, form the main central stem of the Non-Decidua, and include some of the most important of our domestic animals, as the hog, the cow, and the horse, with a large number of extremely interesting families, both living and extinct. The ungulates appeared in the Eocene Tertiary with members closely related to the Zonarians as well as to

the Discoidans, the whole circle of Monodelphians being, at first, closely related to each other.

The ZONARIANS, so called because in this group the placenta is in the form of a zone, include the Proboscidi-ans, the Carnivores, and Hyracoidea.

The elephant is the only living remnant of the extensive order PROBOSCIDIA, which flourished in the Eocene, and which produced the *Uintotheriums*, *Dinotheriums* and *Mastodons* of the Past. This group is closely connected with the ungulates, rising on a higher plane from the whole stem of the Non-Decidua. The Proboscidi-ans are closely connected with *Sirenia* as well as with the ungulates.

HYRACOIDEA is represented at the present day only by the conies of the East. It would not be wonderful if some of the Eocene Mammals should be found to belong here, as for instance, Hyracotherium and its allies.

Intermediately between the Proboscidia and Hyracoidea, proceeds the main stem of the Zonarians, the CARNIVORA, with a full development of living species. Its ascending plantigrade branch rises to meet members of the Discoida, more especially those of the Quadrumanous divisions, at the same time that it recalls the Edentate *Vermilinguia*, and the Sloths. The opposite branch of the *Pinnipedes* descends to recall the old *Zeuglodonts* of the Cetacea. The typical carnivores are undoubtedly to be found in the *Cynoidea*, of which the Dogs are the central forms. These show more tendency to vary under domestication than do any other carnivores. A similar tendency is seen among ungulates.

The central and terminal stem of Monodelphia is DISCOIDA. It derives its name from the form of the placenta, which is here discoidal. To this group belong the *Rodents*, the *Insectivora* (including *Cheiroptera*), the *Prosimiæ*, the *Simiæ*, and the central and terminal stem of *Hominina* or Man.

The two lower branches, *Rodentia* and *Insectivora*, include animals which, whilst possessing the essential characters of the group, are inferior in brain development. They compensate for the extraordinary cerebral perfection which characterizes man.

The Prosimians and Simians together are termed Quadrumana. These, with the Rodents and Insectivora, form a whorl of four lateral branches around the main stem or axis of the group.

The connection between the Prosimians and the Insectivora is made by *Galeopithecus*, or the Flying Lemur, an animal held to be an insectivore. On the side towards the Rodents, the *Cheiromyini*, or the Aye-Aye, forms the link of connection. The Marmosets, considered as the lowest of the Simians, would seem to be equally well placed if held to be the highest group of the Prosimians. They are without an opposable thumb, as in one of the Lemurs,—the Aye-Aye. When the face looks forward, as it does in the squirrel-like posture natural to these animals, the base of the brain is almost horizontal to the spinal column, as in the erect human being. The brain case is also relatively very large, although, like the Lemurs, the Marmosets are smooth-brained animals. In the brain there is an excess in quantity combined with inferior quality. The teeth in the Marmosets are thirty-two

in number, as in the highest of the Apes and in Man. Like the Lemurs, these animals are thickly furred, their whole aspect being that of the *types* of their group. For these reasons it seems justifiable to regard them as more Lemurine than Simian. Considered as the central and highest branch of the Lemurs, and in certain respects on a level with the Simians, the peculiarities of their structure become instructive, and their relation to the lower Cebidæ intelligible.

Without the Marmosets, there are three families of Simiæ. The *Cebidæ* or Platyrrhine monkeys, are found only in South America. In this family of Simiæ the rodent analogies are most clearly shown. The relationship does not appear to be one of close affinity.

The Catarrhine Apes, belonging to the old world, include two families. The typical Carnivores are recalled in the *Cynopithecidæ* or dog-like apes. The central and highest family of the Simiæ is the Simiidæ, otherwise known as *Anthropomorpha* or Man-like Apes. To this family belong the Gibbons, the *Orangs*, the *Chimpanze*, and the *Gorilla*. These Apes do not constitute an ascending series towards man, but the similarities are found in the family as a whole, some genera presenting likenesses not found in others, while the latter show different resemblances. The meaning of this appears to be that the whole branch of the apes diverged from its root with man-like characters, and that in time these came to be represented by different species, which diverged more and more widely from the main central stem *Hominina*. This view is strongly confirmed by the more anthropomorphous appearance of the young Simiidæ, which indicates the

superiority of the root stock from which this family is derived. The extinct forms are *Pliopithecus* and *Dryopithecus*. These are considered, by very good naturalists, to be more man-like than any of the existing Apes, as they should be if the above theory is the correct one.

The group known as the Primates is composed of both branches of the Quadrumana, and Hominina. There can be no doubt, although connecting forms are as yet wanting, that the extinct pachydermatous Quadrumana of the Eocene were the generalized forms from which arose these three lines of development. These pachyderms were neither true lemurs, monkeys, apes, nor men, but were closely related to extinct ungulates, carnivores, proboscidiens, rodents, and insectivores. They had the dental arches unbroken by a diastema as in man, which was the case with a large number of the Eocene Monodelphians.

It has been no part of my purpose to give the characters of the different groups in the animal kingdom. My object has been to show how, by the simple method of bichotomous branching, whorls of four great groups are formed in succession around a main trunk of comprehensive forms, from the Protozoa up to the Discoida, and that man arises in the axis of development for the whole animal kingdom; that he existed as the flower exists in the seed, and that in the line of his coming he lifted all below him and held them at a higher level. As yet there is no proof that this central stem *Hominina* budded from its base earlier than the Quaternary period. If the great law of Progress continued without interruption, Man arose at first on

a far higher round than his lateral congeners. The central stem has been shown to be the highest from the Metazoans which arose from a Protozoan base ; the vertebrate from the invertebrate ; the mammal from the lower classes ; the monodelphian from the implantationals, and the discoidans from the lower monodelphians. There is no reason to suppose that a general law failed here, but every reason to believe that with successive changes the rise in development became infinitely important. If bone for bone, muscle for muscle, and every other physical character could be shown to be more similar in man and the apes than naturalists admit, the distinction between them would still remain one of the broadest in nature. In man, THOUGHT FORCE gained its true terrestrial exponent, and the Soul beamed from its tenement to work all the wonders it has wrought. Nothing paramount to this occurred earlier : not even the change from inanimate to animate matter was a rise so grand, so fruitful in results as this.

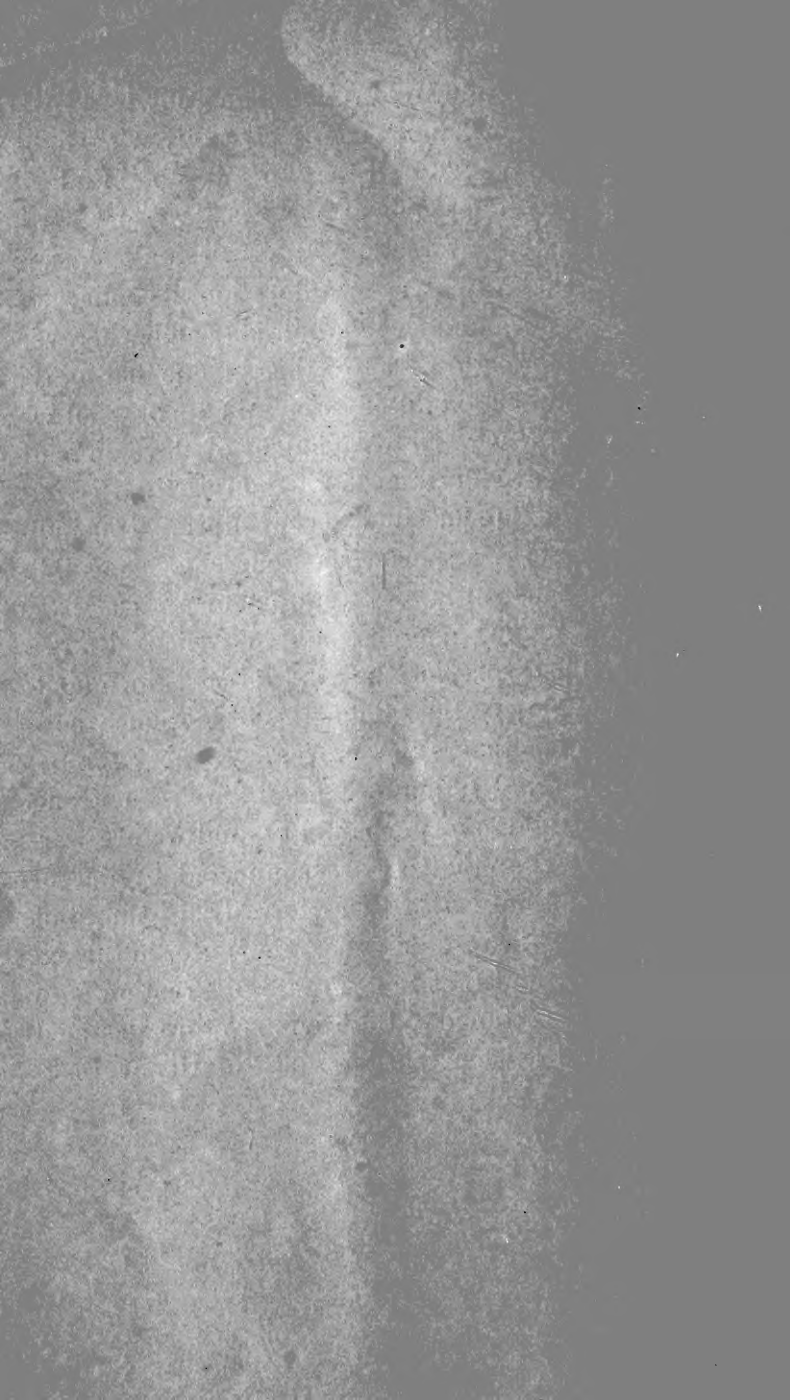
But as the forces and tendencies of intellectual life lie sleeping in the ovule from which is evolved the individual man, so in the germ of Being residing in atoms of ether, may sleep the forces and tendencies of immeasurable spiritual power. The erect, large-brained thinker was ordained, when atoms ranged themselves by their *axes of rotation*. This intelligent being is a necessity of the eternal activities of nature, which, working under the guidance of the Divine Ordainer, must produce good, better, best. Atomic Force, Molecular Force, Growth Force, Nerve Force, Thought Force, Spiritual Power, these succeed each

other because the universe is living and not dead ; because the Supreme Soul vivifies eternally with light and life and love,—with all the attributes of Mind.

Considering Life as one of the cosmical forces resulting from the interaction of Spirit and Matter, coeval with God and eternal in duration, its sphere of activity must be boundless as infinitude ; and, wherever all the forces of nature act together in due harmony, there must Life be exhibited in one phase or another of its development. To what height of development it may arise above anything known on earth, it is impossible for the human mind to conjecture. Our individual duty is to rise as near the Source as is possible to each, and thus aid in elevating our own race.

That one single sphere should be selected as a theater for the display of the vital forces is incompatible with the play of the whole class of motions whose proper field of action is the universe. The improbability of the partial action of general laws is so strong as to bear the stamp of impossibility, and we are warranted in believing that we are connected by ties of relationship not only with every terrestrial being, but also with those existing on every life center in the expanse beyond ; and that the Purpose of Creation is to multiply beings attuned to the Divine Nature, destined to an immortal existence in the midst of His everlasting harmonies.

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